

REMARKS

Claims 1-27 are pending in the present Application. Applicant amended claims 1, 15-18, and 20-25 and added new claims 26-27. All amendments are supported by the specification.

Objections - 37 CFR 1.83(a)

The Examiner objected to the drawings under 37 CFR 1.83(a). The Examiner stated:

“Therefore, the resonant link DC link, comprising only one auxiliary power device must be shown”

In response, Applicant respectfully points to the arguments below, which clarify the claim term “auxiliary power device.” In light of that argument, no modification of the drawings is necessary.

Claim Rejections - 35 USC § 112

The Examiner rejected claims 1-25 under 35 USC § 112. The Examiner stated:

“Claims 1-25 are rejected under 35 U.S.C. 112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which applicant regarding as the invention.

Claims 1, 21, 23 and 24 all claim having a resonant DC link comprising only one auxiliary power device. This limitation is vague and indefinite. The applicant has not distinguished what exactly a power device is and an auxiliary one at that. In other words, being an "auxiliary power device" does not distinguish between circuit components. Any circuit component can be a "power device" as well as an "auxiliary power device." Any device that consumes power, such as a diode, inductor, switch, resistor, capacitor, transformer etc, can be a power device and an auxiliary power device. Thus, for the applicant to claim that there is only one power device, while the specification and drawings illustrate many power devices, is vague and confusing rendering the claims indefinite; and therefore, the limitation will be ignored in order to examine the claims on their merit. Claims 2-20 and 25 inherit the same through dependency.”

In response, Applicant respectfully remarks that the claim term “auxiliary power device” has been amended to “power transistor” throughout the claims. This amendment clarifies the type of circuit component referred to by the claim term. Therefore, Applicant respectfully submits that this amendment overcomes the rejection and makes the claim definite.

Claim Rejections - 35 USC § 102

The Examiner rejected Claims 1-3, 5-9, 11-25 under 35 U.S.C. 102(b) as being anticipated by Lauw (US 5,559,685). The Examiner stated:

Claims 1, 20, 21 and 23-25; Lauw et al, figure 4, disclose a converter circuit, comprising: an AC-to-DC converter (20), comprising a plurality of first power devices (21-23); a resonant DC link (30), comprising at least one auxiliary power device (S_{C1} , S_{C2}); a DC-to-AC converter (10), comprising a plurality of second power devices (BH_1 - BH_3 , BL_1 - BL_3); and DC link lines (32, 35), coupling the AC-to-DC converter, the resonant link, and the DC-to-AC converter, wherein the auxiliary power device (S_{C1} , S_{C2}) is coupled between the DC link lines.

Claims 14-16; Divan discloses a resonant capacitor (C_C or C_S or C_R); a diode (D_C); and a switch (S_{C1} , S_{C2}); coupled between the DC link lines and parallel with each other.

Claims 17 and 22; figure 3 – (S_{C2}).

Claims 18 and 19; first capacitor (C_C), auxiliary power device (S_{C1} , S_{C2}), resonant capacitor (C_R), inductance (L_R), second capacitor (C_S).

In response, Applicant respectfully points out that Lauw does not recite several claim elements and therefore does not anticipate independent Claims 1, 20, 21, 23 and 24, and their dependent claims.

1. Lauw does not recite: “a converter circuit having only one power transistor”. Visibly, Lauw has two power transistors S_{C1} and S_{C2} .

Implementing an additional power transistor in the DC link line of the converter considerably increases the power loss and thus reduces the efficiency. It also requires the introduction of an additional power controller device. In particular, an additional gate driver is required. Since the additional power transistor is in the high voltage DC link line, the gate driver has to be isolated from the ground. Also, an additional timing control signal has to be

generated as well. Because of all these requirements, implementing a second power transistor introduces considerable complexity, increases the price and reduces the efficiency of the circuit. Therefore, a converter circuit with only one power transistor is qualitatively better than converters with two power transistors. Because of this distinctive difference, independent Claims 1, 20, 21, 23 and 24 are patentable over Lauw.

2. Lauw does not recite a converter, where “a first terminal of the power transistor is connected to the first DC link line, and a second terminal of the power transistor is connected to the second DC link line”. Visibly, power transistors Sc1 and Sc2 are in the main DC link lines, instead of between them. Therefore, both of their terminals are connected to the same DC link line (“the first DC link line”).

As explained earlier by the Applicant, moving the power device from being in the DC link lines to being between the DC link lines brings about crucial improvements.

To appreciate this point more clearly, Applicant refers to the timing diagram of FIG. 4. In FIG. 4, the current $i_{Qr}(t)$ represents the current through the auxiliary power device. Current $i_{Qr}(t)$ is essentially zero over most of the operating cycle of the converter. Quantitatively, in embodiments the current $i_{Qr}(t)$ is non-zero for less than 10% of the operating cycle, as can be appreciated from comparing the duration of the current spike between t_0 and t_1 , and the length of the entire operating cycle between t_0 and t_7 . In some embodiments this ratio is less than 2%. Therefore, power devices, which are coupled between the DC links, have a current flowing through them only a few percent of the operating cycle. In contrast, the current in the main DC link is a steady, DC current. Thus, power devices coupled into the DC links have a current flowing through them essentially the entire operating cycle. This clearly demonstrates that converters with power devices coupled between the DC links reduce the power loss 10-50 times ($=100/10$ to $100/2$, the ratio of the on-times of the two types of converters). This is very clearly a critical difference between the two types of converters. Because of this distinctive and critical difference, independent Claims 1, 20, 21, 23 and 24 are patentable over Lauw.

3. Lauw does not recite a converter, where “the resonant DC link is operable to clamp an operating voltage of the converter.”

Since Lauw's power transistors are not connected to the ground, they are unable to clamp the operating voltage of the converter. As described in the Response to the First Office Action, the operating voltage can have spikes reaching 800-1000 Volts in unclamped converters like Lauw's. This value represents a 2-3 fold increase over the regular operating voltage. In contrast, embodiments of the present invention clamp the voltage close to the operating voltage, around 300-400 Volts. It is evident that losses during the spikes are much higher in unclamped converters than in clamped converters. Further, power transistors with much higher voltage ratings have to be used in unclamped converters, making their manufacture more expensive and eventual price higher. Because of these distinctive and critical differences, independent Claims 1, 20, 21, 23 and 24 are patentable over Lauw.

In sum, Lauw does not recite at least three elements of independent Claims 1, 20, 21, 23, and 24 and therefore does not anticipate independent Claims 1, 20, 21, 23 and 24. Furthermore, Applicant demonstrated that embodiments of the present invention offer critical improvements over Lauw, including a factor of 10-50 improvement in efficiency, a factor of 2-3 reduction in voltage ratings of the power device, and a profound reduction in circuit complexity and price. At least for all these reasons, independent Claims 1, 20, 21, 23, and 24 are patentable over Lauw.

Dependent Claims 14-19, 22 and 25 depend from allowable independent Claims 1, 21, and 24 and are therefore themselves allowable.

Applicant notes that the reference to Divan in relation to Claims 14-16 was probably misplaced. Judging from the labels and explanations, which are present in Lauw but not in Divan, furthermore that Divan is listed as a reference not relied upon, Applicant respectfully assumes that the reference to Divan was misplaced and therefore did not respond to those points of rejection in the Office Action.

Claim Rejections - 35 USC § 103

The Examiner rejected claims 4 and 10 under 35 U.S.C. 102(b) as being anticipated by Lauw et al. (US 5,559,685) in view of Lee et al. (US 5,633,793). The Examiner stated:

Claims 4 and 10; Lauw et al discloses the claimed subject matter in regards to claims 3 and 9 supra except for the power transistors comprises a first power diode being coupled between a source and a drain of a MOSFET first power transistor.

Lee et al teaches that each bridge switch of a converter and rectifiers has an anti-parallel diode associated therewith; and it is understood that these anti-parallel diodes may be either discrete components or the body diode in the case of an active switch such as a MOSFET.

Therefore, it would have been obvious to one having ordinary skill in the art at the time the invention was made to modify Lauw et al to incorporate power diodes coupled between a source and a drain of a MOSFET in order to utilize the current carrying characteristics of MOSFETs as switching devices and as suggested by Lee et al.

Claim 4 depends from independent Claim 1, which has been shown to be allowable. Therefore, Claim 4 is allowable as well.

Furthermore, Applicant respectfully points out that the Examiner did not provide any explicit motivation to combine these two references, whereas any obviousness type rejection must contain such an explicit motivation, as stated by the Federal Circuit and the MPEP.

Moreover, Lauw, even in combination with Lee, does not recite the following claim elements and therefore does not make Claim 1, and its dependent claim, Claim 4 obvious.

In FIG. 6, Lee describes three switching/power devices in a block, which may be related to the resonant DC link: D, Daux and Saux. In contrast, Claim 1 recites “a resonant DC link, comprising only one power transistor”. Therefore, Lauw, in combination with Lee, does not anticipate this claim element.

Also, given that the polarity of Saux is opposite of auxiliary power diode 124 in FIG. 1 of the present application, even if Lee is combined with Lauw, the resulting converter is unable to clamp the operating voltage. In contrast, Claim 1 recites: “the resonant DC link is operable to clamp an operating voltage of the converter.” Therefore, Lauw, in combination with Lee, does not anticipate this claim element.

The Examiner also noted that

“Lee et al teaches that each bridge switch of a converter and rectifiers has an anti-parallel diode associated therewith; and it is understood that these anti-parallel diodes may be either discrete components or the body diode in the case of an active switch such as a MOSFET.”

In response, Applicant respectfully notes that Lauw itself already describes anti-parallel diodes existing across the switching devices Sc1 and Sc2. The Examiner is correct, it is widely understood that these diodes can be explicit or implicit body diodes. Therefore, combining Lauw with Lee in the manner described by the Examiner does not introduce any new ground of rejection.

Finally, Applicant notes that Lee describes having a switching device D in the main DC link, once again disadvantageously leading to large power losses.

In summary, combining Lauw with Lee in the manner described by the Examiner lacks motivation. Further, this combination neither recites several claim elements, nor makes them obvious. For all these reasons independent Claim 1 and its dependent claim, Claim 4 is allowable over Lauw, even in combination with Lee.

CONCLUSION

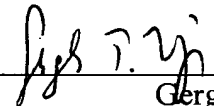
In light of the above remarks and with the above amendments, Applicant respectfully submits that all pending claims are in condition of allowance and therefore their allowance is requested. If any of the claims require further clarification or discussion, the undersigned is readily available at (415) 772-1200.

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